CYTOLOGICAL AND MORPHOLOGICAL OBSERVATIONS IN *GALINSOGA* AND RELATED GENERA (ASTERACEAE)

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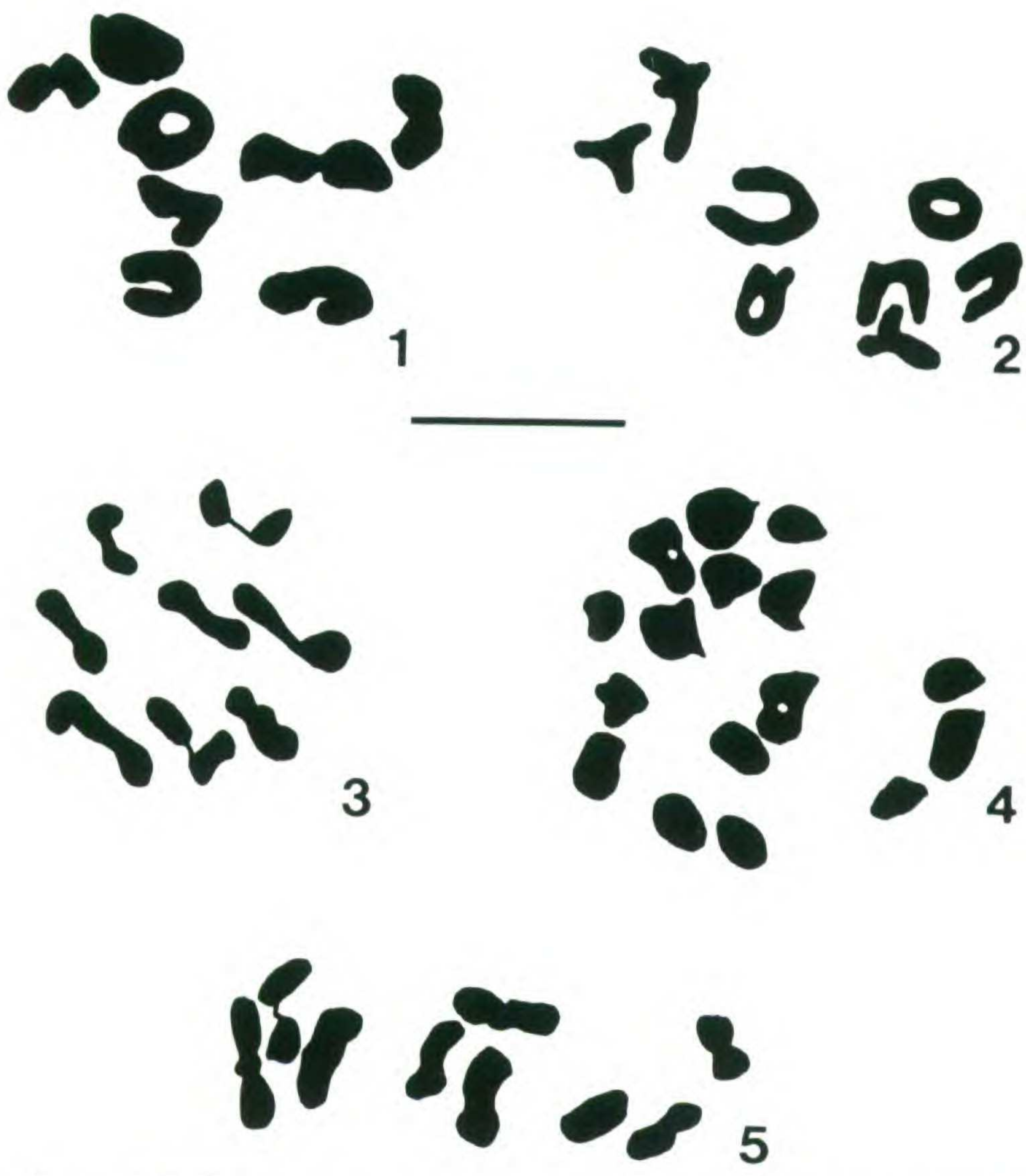
ABSTRACT

Chromosome counts are provided for numerous populations representing nine taxa of *Galinsoga*, one species of *Cymophora*, two species of *Sabazia* and one of *Tridax*. Four of the counts for *Galinsoga* and one for *Cymophora* are newly reported. Morphological observations are offered for several of the species known previously only from type specimens or from few collections. Taxonomic ramifications of the cytological and morphological data are discussed.

Since the appearance of recent taxonomic works concerning *Galinsoga* Ruiz and Pavon (Canne, 1977a) and *Cymorphora* B. L. Robins. (Turner & Powell, 1977) field work in Mexico has yielded collections of poorly known members of these genera in addition to species of the closely related *Sabazia* Cass. and *Tridax* L. Chromosome counts for these Mexican collections are indicated in Table 1 along with a few counts from other regions. Discussion of the taxonomic significance of the cytological observations are included below where pertinent. Morphological observations are added for certain members of the genera that have been known only from type collections or from a small number of collections.

MATERIALS AND METHODS

Buds were fixed in the field in modified Carnoy's fluid (chloroform:absolute ethanol:acetic acid, 4:3:1) and later transferred to 70% ethanol for laboratory storage. Whole buds of capitula were stained for at least 24 hours in Snow's stain before disc florets were squashed in Hoyer's solution for observation of meiotic stages. Root tips for mitotic observations were obtained by germination of achenes on moist filter paper in petri plates. Harvested root tips were treated in a cold, saturated, aqueous solution of paradichlorobenzene for 3–4 hours, fixed for at least 1 hour in a solution of ethanol:chloroform:acetic acid (3:1:1) and then treated as described above for buds. Drawings of all counts were made at a magnification of 2500× with a Zeiss drawing device. Voucher specimens are on deposit at OAC. Scanning electron micrographs of achenes were made at 25Kv on a Jeol JSM-35C scanning electron microscope.



Figures 1-5. Drawings of meiotic chromosomes of *Galinsoga* and *Cymophora*. **1.** *G. glandulosa*, $n = 8$, metaphase I, *Canne & Woodland 1950*. **2.** *G. triradiata*, $n = 8$, diakinesis, *Canne & Funk 1008*. **3.** *G. longipes*, $n = 8$, metaphase I, *Canne & Woodland 1970A*. **4.** *G. parviflora* var. *semicalva*, $n = 16$, metaphase I, *Keil 13396*. **5.** *C. hintonii*, $n = 9$, metaphase I, *Canne & Funk 1030*. Scale = 10 μm.

RESULTS AND DISCUSSION

Galinsoga section **Elata**

Of the four species in sect. *Elata* only *Galinsoga durangensis* (Longpre) Canne has been known from collections other than those from the type locality. The $n = 8$ count reported here for *G. durangensis* confirms previous reports, and was made from a collection at the type location. A recent search for populations of *G. formosa*

Canne proved unsuccessful, and *G. formosa* and *G. mollis* McVaugh remain unknown cytologically.

When first described, *Galinsoga elata* Canne was known only from a single collection locality in Queretaro. Four additional collections were made recently from near this area. Counts from three of these populations confirm the single previous count and establish the base chromosome number as $x = 8$. In the field, plants of *G. elata* are usually less than 0.5 m tall and are often less than 0.1 m tall. Under greenhouse conditions, however, plants assume heights of over 2 m. Field plants of the related *G. mollis* and *G. formosa* are known to reach 1.5 m and 1.0 m respectively.

Galinsoga section **Stenocarpha**

The chromosome number of *Galinsoga filiformis* (S. F. Blake) Canne was reported first as $n = 8$ (Turner 1965, as *Stenocarpha*) then later as $n = 9$ (Solbrig et al., 1972, as *Stenocarpha*). Additional counts reported here from collection *1038* by *Canne and Funk* were $n = 8$ pairs and $n = 8$ pairs plus one supernumerary pair. The small supernumerary pair appears to proceed normally through meiosis and probably accounts for the $n = 9$ count reported by Solbrig, et al. (1972). Mitotic preparations from root tips of germinated achenes from a second population *(Canne & Funk 1044)* yielded counts of $2n = 16$ and an occasional $2n = 16 + 2$ small supernumeraries (Table 1).

Galinsoga section **Galinsoga**

In a recent revision of *Galinsoga* (Canne, 1977a) three new species, *G. glandulosa, G. triradiata* and *G. longipes,* were described from south central Mexico. As noted in the revision, *G. glandulosa* is somewhat anomolous in the genus with its triangular dentate leaves, glandular anther appendages, and weakly cuspidate, ciliate paleae. Known previously only from the type specimen, this species is reported here to have a haploid number of $n = 8$, (Fig. 1, Table 1).

The relatively poorly known, but morphologically distinctive, *Galinsoga triradiata* was counted from two populations as $n = 8$ and $2n = 16$ (Fig. 2, Table 1). At the time of its original publication *G. triradiata* was known only from specimens having epappose achenes. Although these epappose achenes may be glabrous, they

Table 1. **Chromosome numbers of *Galinsoga, Cymophora, Sabazia & Tridax*.**

Taxon[1]	Count	Voucher (OAC)[2]	Locality[3]
Galinsoga Ruiz & Pavon			
G. durangensis (Longpre) Canne	$n = 8$	*C & F 1051*	Durango:7.5 mi. NE of Revolcalderos.
G. elata Canne	$2n = 16$	*C & W 1940*	Queretaro:4.4 km. SW of Pinal de Amoles.
	$2n = 16$	*C & W 1942*	Queretaro:1.3 km. NE of Pinal de Amoles.
	$2n = 16$	*C & W 1944*	Queretaro:1.5 km. NE of Pinal de Amoles.
G. filiformis (S.F. Blake) Canne	$n = 8$, $n = 8 + 1$ supernumerary pair	*C & F 1038*	Sinaloa:Mex. 40, 1.7 mi. SW rd. to Santa Lucia.
	$2n = 16$, $2n = 16 + 2$ supernumeraries	*C & F 1044*	Sinaloa:Mex. 40 at jct. rd. to Santa Lucia.
G. glandulosa Canne*	$n = 8$, $2n = 16$	*C & W 1950*	Queretaro:15.6 km. SW of El Madroño.
G. longipes Canne*	$n = 8$	*C & W 1970A*	Mexico:0.7 km. S of Temascaltepec.
	$2n = 16$	*C & W 1971*	Mexico:5.4 km. SW of Temascaltepec.
G. parviflora Cav. var. *parviflora*	$2n = 16$	*C & W 1931*	Morelos:3.1 km. E of Yautepec.

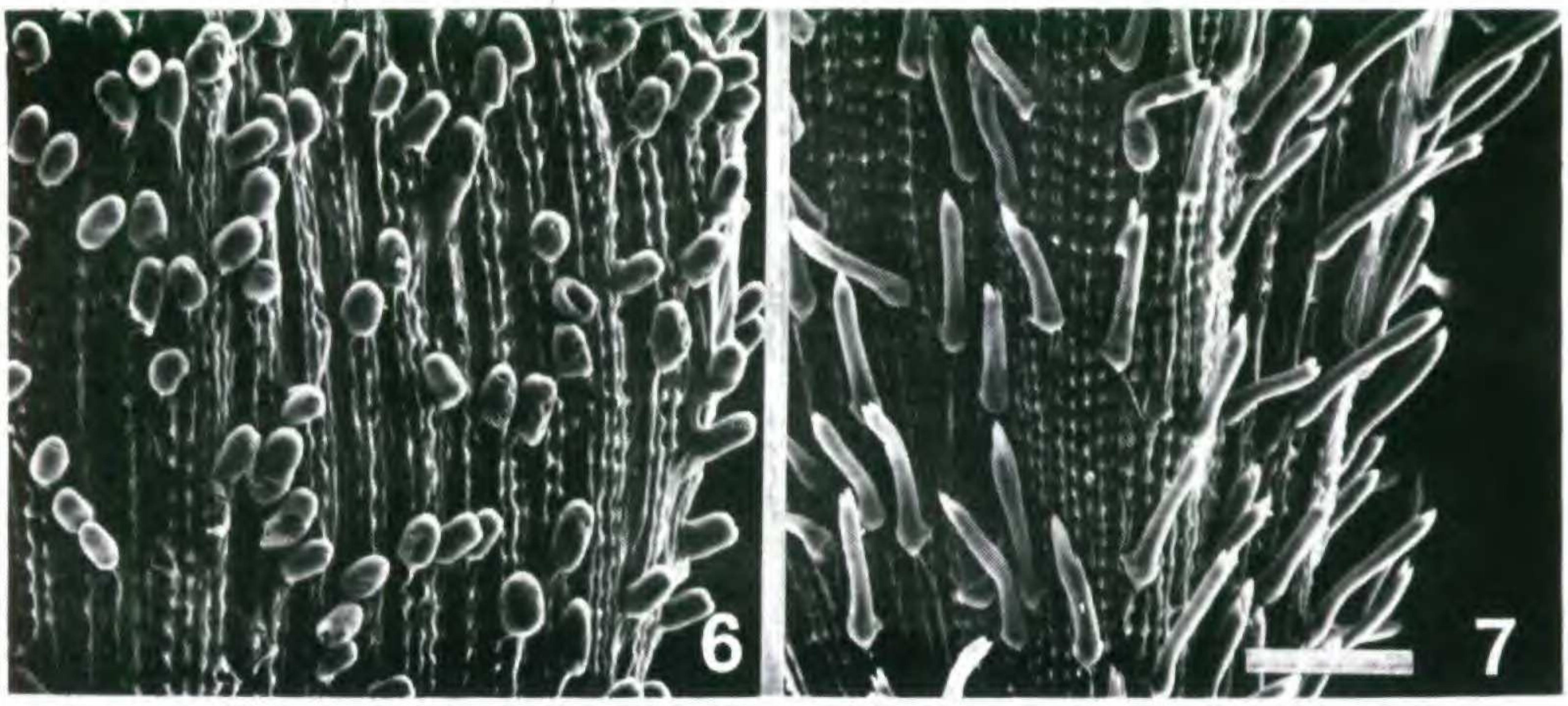
	$2n = 16$	*C & W 1991*	Distrito Federal:1.7 km. NW of Santa Ana Tlacotengo.
	$2n = 16$	*C & W 1992*	Distrito Federal: Xochimilco.
	$n = 8$	*H & F 4270*	Michoacan:10 mi. W of Zamora.
	$n = 8$	*H & F 4228*	Mexico:5 mi. SW of Toluca.
	$2n = 16$	*C 2172*	Australia: New South Wales, Sydney.
	$2n = 16$	*C 2174*	Papua New Guinea:Western Highlands, Mt. Hagen.
	$2n = 16$	*C 2175*	Papua New Guinea:Eastern Highlands, Goroka.
	$2n = 16$	*C 2177*	Papua New Guinea: Morobe, Mt. Kaindi.
G. parviflora Cav. var. *semicalva* A. Gray*	$n = 16$	*D. Keil 13396*	Chihuahua:N side Colonia Garcia.
G. quadriradiata Ruiz & Pavon (representative counts)	$n = 16$, $n = 6_{II} + 20_{I}$ to $10_{II} + 12_{I}$	*C & F 1024*	Michoacan:rd. to Dos Aqua, 9.5 mi S jct. rd. to Coalcomán.
	$2n = 32$	*C & W 1927*	Oaxaca:13.8 km. N of San Jose Pacifica.
	$2n = 32$	*C & W 1945*	Queretaro:1.5 km. NE of Pinal de Amoles.

Table 1. continued

Taxon[1]	Count	Voucher (OAC)[2]	Locality[3]
G. quadriradiata Ruiz & Pavon (representative counts) (continued)	$n = 16$	*C & W 1954*	San Luis Potosi:Mex. 85, 1.2 km. N of Hidalgo border.
	$n = 16$, $2n = 32$	*C & W 1970B*	Mexico:0.7 km. S of Temascaltepec.
	$n = 16$	*H & F 4216*	Guerrero:5 mi. E of Taxco.
	$n = 16$	*H 3900*	Panama:Chiriqui:between Horqueta and Cerro Horqueta.
G. triradiata Canne*	$n = 8$, $2n = 16$	*C & F 1008*	Michoacan:8.8 mi. E of Uruapan.
	$2n = 16$	*C & F 1011*	Michoacan:7.7 mi. N of Barranca Honda, S of Uruapan.
Cymophora B. L. Robins.			
C. hintonii Turner & Powell*	$n = 9$, $2n = 18$	*C & F 1030*	Michoacan:17 mi. W of Villa Victoria.
Sabazia Cass.			
S. humilis (H.B.K.) Cass.	$n = 4$	*C & W 1883*	Mixico:SE of Amecameca.
	$2n = 8$	*C & W 1961*	Mexico:Mex. 15, 4.1 km. E jct. rd. to Ocoyoacac.

	$2n = 8$	*C & W 1962*	Mexico:6.6 km. SW of jct. Mex. 134 & Mex. 130.
	$2n = 8$	*C & W 1964*	Mexico:3.2 km. NE of San Francisco Oxtotilpan.
	$2n = 8$	*C & W 1976*	Mexico:Palo Mancornado.
	$2n = 8$	*C & W 1989*	Morelos:Mex. 95, 9.8 km. S of Distrito Federal border.
S. liebmannii Klatt	$2n = 48$	*C & W 1922*	Oaxaca:6.4 km. N of San Jose Pacifica.
	$2n = 48$	*C & W 1929*	Oaxaca:15.1 km. N of San Jose Pacifica.
Tridax L.			
T. mexicana A. M. Powell	$n = 9$	*C & F 1016*	Michoacan:5.1 mi. N of Barranca Honda, S of Uruapan.
	$2n = 18$	*C & W 1895*	Puebla:9.7 km. N of Jualillos.
	$2n = 18$	*C & W 1897*	Puebla:3 km. S of Salitrillo.

[1]Asterisk indicates new count.
[2]C = J.M. Canne, F = V. Funk, H = R. Hartman, W = D. W. Woodland.
[3]Localities are from Mexico unless indicated otherwise.



Figures **6** & **7**. Scanning electron micrographs of achenes of *Galinsoga triradiata*. Fig. **6**. Short, blunt trichomes on epappose achene *(Canne & Funk 1008)*. Fig. **7**. Elongate, bifid trichomes on pappose achene *(Canne & Funk 1011)*. Scale = 100 μm for both figures.

usually bear a slight to dense pubescence of reddish colored, short, blunt trichomes that are characteristic of the species (Fig. 6).

One of the recent collections *(Canne and Funk 1011)* contains individuals with epappose achenes and individuals with pappose achenes. All achenes on nineteen plants of a second collection *(Canne and Funk 1008)* are entirely epappose. The curiosity here is not that pappose achenes exist, but that the peculiar trichomes typical of *Galinsoga triradiata* are not present on pappose achenes. These achenes, like those in other species of the genus, have trichomes composed of two unequal, elongate cells (Fig. 7). The pappus of disc achenes consists of 15 to 20 obtuse to acuminate, obovate, fimbriate, white scales. The pappus is either lacking on ray achenes or is composed of a few reduced scales, a situation characteristic of several other species of *Galinsoga* as well.

Galinsoga longipes, a species similar in many regards to *G. triradiata* (Canne, 1977a), also has $n = 8$ and $2n = 16$ (Fig. 3, Table 1). This taxon is the diploid most similar morphologically to the tetraploid weedy *G. quadriradiata* Ruiz and Pavon. Collections *1970 A* and *B* by *Canne and Woodland* from a single mixed population consist of *G. longipes* and the morphological variant of *G. quadriradiata* characterized by white rays, tall narrowly conic receptacle, shallowly trifid paleae, eglandular trichomes, and peduncles averaging longer than 2 cm. This is the variant of *G. quadriradiata* morphologically most similar to the diploid *G. longipes*. All counted specimens of *G. quadriradiata* and *G. longipes* from this mixed population were $n = 16$ (or $2n = 32$) and $n = 8$ respectively. There is no cytological or morphological evidence to indicate hybridization and the formation of triploids or higher order polyploids between these two apparently closely related taxa.

The representative counts reported here at $n = 16$ and $2n = 32$ for *Galinsoga quadriradiata* are consistent with previous records for plants from Mexico and Central America (Table 1). In addition, eight populations from Michoacan, three from Mexico, two each from Hidalgo and Oaxaca, and one each from Guerrero, Puebla, Queretaro, and Sinaloa were counted at $n = 16$ or $2n = 32$. Voucher data are available from the author. Canne (1977a) noted earlier that there are at least three internally variable morphotypes of *G. quadriradiata* and that hybrids among them abound. The reduced male fertility and meiotic irregularities in the hybrids, however, indicate that these morphological variants are not fully compatible sexually (Canne 1977a).

Collection *1024* by *Canne and Funk* from western Michoacan offers an illustration of the interbreeding of two of these morphotypes of *G. quadriradiata*. Among the 19 plants collected from this population were 7 specimens of a variant typified by ray corollas that turn pink when dried and are deeply trilobed; ray achenes 1.4–1.9 mm long; paleae essentially entire and 0.5 mm or less in width; achenes epappose; peduncles with abundant glandular-tipped trichomes; disc florets 20 or fewer per head. Nine specimens of the second variant are characterized by ray corollas that remain white when dried and are shallowly trilobed; ray achenes 1.2–1.5 mm long; paleae irregularly trifid and 0.5 to 1.1 mm in width; achenes pappose; peduncles with eglandular trichomes; disc florets usually 25 to 35 per head. Pollen stainability in lactophenol cotton blue ranged from 67% to 94% for the pink rayed variant and from 69% to 97% for the white rayed variant.

Among the 19 plants three appear to be f_1 hybrids having an intermediate morphology characterized by ray corollas tinged with pink; paleae within a head entire to irregularly trifid; achenes epappose or with a short pappus; and sparse to dense peduncular pubescence of glandular trichomes. Pollen stainability ranges from 12% to 27% for these plants. The majority of pollen grains are empty, very small or malformed. Few mature, black achenes were produced, generally only 1 to 3 per head. Meiosis in the presumed hybrids was irregular with the formation at metaphase I of 6 bivalents and 20 univalents to 10 bivalents and 12 univalents. Lagging chromosomes, anaphase bridges, and the production of micronuclei were common.

All parental types and hybrids of the variants of tetraploid *Galinsoga quadriradiata*, including those from collection *1024*, grown under greenhouse conditions were self compatible. Bagged heads set full complements of fruit in parental types but produce reduced set in hybrid plants. The self and cross-compatibility of the variants of *G. quadriradiata* and the viability of hybrid achenes have in part lead to the mosaic of morphological variation seen in this species in Mexico (Canne, 1977a). The mode of origin of the Mexican tetraploid morphotypes is not known. The presence of at least three morphological variants that are only partially sexually compatible could have resulted from alloploid origins with the sharing of at least one parent among the variants.

All specimens of typical *G. parviflora* Cav. that have been counted to date are diploids at $n = 8$ (Canne, 1977a, and Table 1). I have accepted as synonomous with *G. parviflora* a morphological variant that has paleae more shallowly trifid, smaller leaves and a stricter growth habit than are usual for typical *G. parviflora*. This variant, *G. parviflora* Cav. var. *semicalva* A. Gray, occurs primarily in Arizona, New Mexico, and neighboring regions of Chihuahua. The overlap in distribution and morphological intergradation with typical *G. parviflora* prompted me to treat these plants informally as variants until more was known of them (Canne 1977a). A count reported here for this variant as $n = 16$ lends credence to the opinions of Gray (1853) and St. John and White (1920) that formal recognition is appropriate. Accordingly, the tetraploid is listed in Table 1 as *G. parviflora* Cav. var. *semicalva* A. Gray.

Cymophora

This small genus has met with considerable attention of late because of its purported taxonomic position between *Tridax* and *Galinsoga* (Turner, et al., 1973; Turner & Powell, 1977; Canne, 1977b). The chromosome number of *Cymophora hintonii* Turner and Powell is reported for the first time here as $n = 9$ from a single collection in Michoacan near the Colima border (Fig. 5, Table 1). Root tips from germinated achenes repeatedly yielded counts of $2n = 18$. Of the four species of *Cymophora* the only other taxon for which a chromosome number is known is *C. pringlei* B. L. Robins with $2n = 16$ (Turner et al., 1973). Thus, if *C. hintonii* is uniformly $n = 9$, the genus is dibasic at $x = 8$ and 9.

Interestingly, there are now counts for one species from each of the species pairs in the genus. *Cymophora accedens* (S. F. Blake) Turner & Powell and *C. pringlei* ($n = 8$) have ovate to ovate-lanceolate leaf blades on short petioles, phyllaries and paleae with a few pronounced veins, and moderately to densely pubescent disc achenes. In contrast, *C. hintonii* ($n = 9$) and *C. venezuelensis* (Arist. & Cuatr.) Canne have long petiolate, ovate to trullate blades of a thinner texture with coarsely, irregularly serrate to shallowly lobed margins. The phyllaries and paleae are striated and have numerous, inconspicuous veins. The achenes are glabrous to only slightly pubescent. Whether the congruence of the two morphologies with the two chromosome numbers is a reflection of two phyletic units among the four species as suggested by Robinson, et al. (1981) will be more easily evaluated when the chromosome numbers become known for *C. accedens* and *C. venezuelensis*. The quandry over whether this small genus is more closely allied to *Tridax* ($x = 9$, 10), where two species were formerly placed, or to *Galinsoga* ($x = 8$) or *Sabazia* ($x = 8$) is not resolved by the $n = 9$ count for *C. hintonii*.

Sabazia and Tridax

Counts listed in Table 1 for *Sabazia* and *Tridax* are consistent with previously published reports (Longpre, 1970; Powell, 1965).

ACKNOWLEDGMENTS

Research was supported in part by a Natural Sciences and Engineering Research Council of Canada grant to the author. I am very grateful for help in the field from Drs. V. Funk and D. Woodland. I also thank Drs. V. Funk, R. Hartman, and D. Keil for providing bud material and specimens from their collections.

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